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(54) Title: WIRELESS COUPLING OF DEVICES TO WIRED NETWORK
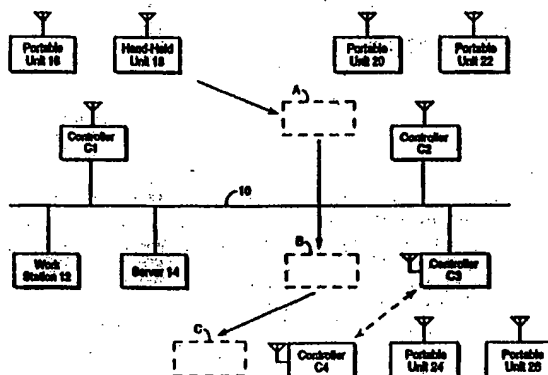
(57) Abstract

Spaced-apart communication controllers (C1, C2, C3, C4) coupled to a cable-based network maintain a portable device (18) in communication with the network for data transfer. Each controller (C1, C2, C3 or C4) communicates with the portable device (18) with data packets transmitted through air, and requires registration of the portable device (18) before offering packet transferring services. The registration process involves transmitting a packet from the portable unit (18) requesting a response from controllers (C1, C2, C3, C4), transmitting a response packet from each controller (C1, C2, C3 or C4) receiving the request, selecting one of the responding controllers (C1, C2, C3, C4) at the portable unit (18) according to criteria that enhance data transfer, and transmitting from the portable unit (18) a packet identifying the selected controller to complete registration. The selected controller transmits a packet confirming the registration to the others via the network cable (10). The controller with which the portable unit (18) was previously registered responds by the de-registering the unit (18) and transmitting any stored packets addressed to the unit (18) via the cable (10) to the newly selected controller. Th portable unit (18) is battery-powered, and a power saving procedure that involves disabling the packet receiving section of the unit (18) is continually adjusted to accommodate transmission rates to the unit (18).

Wireless Coupling Of Devices To Wired Network

Technical Field

The invention relates to networks for transmitting data in packet
5   form, and more specifically, to methods and apparatus for wireless coupling of
devices to a network in which cables are otherwise used to transfer data
between network devices.

Background Art

Networks are known in which the primary transmission medium
10   is a cable characterized by relatively high-transmission rates. Network nodes
connected directly to the cable medium may typically consist of shared network
resources, such as host computers, mass storage media, and communications
ports. To better control data flow and allow a greater number of network users,
the network may be configured as several local area networks (LAN's). Each
15   LAN will comprise a limited number of devices that communicate directly with
one another over local cables. The LAN devices may be coupled to the primary
cable medium by a communication controller which is normally a router or a
bridge. Although a router and a bridge operate in different ways, both
ultimately enable data to be transferred between a device in a particular LAN and
20   a device connected directly to the primary cable medium or located in another
LAN.

The operation of a conventional router is well known. It will
typically create and maintain a table of LAN's within the network. It is
effectively unaware of the devices in the LAN it serves or in other LAN's. A
25   device within its LAN may transmit, for example on start-up, a local packet
requesting identification of a router and the router will transmit a packet
identifying its address for communication. If the devices wishes to
communicate with a device in another LAN, the device may transmit a packet to
the router a packet containing relevant LAN and device addresses and any data
30   required to be transmitted. The router then places the packet on the primary
cable medium. A similar router serving the LAN in which the other device is
located will retrieve the packet from the primary cable medium in response to
the contained LAN address and transfer the packet to its LAN where the other
device can receive the packet.

35   A conventional bridge monitors transmission of packets within
individual LAN's, extracts device addresses from the packets, and builds a table
of such addresses. Unlike a router, it is effectively aware of the network
devices located in individual LAN's. If a particular device in a LAN served by

the bridge transmits a packet addressed to a device in another LAN, the bridge
relies on its table to convey the packet from the source device toward the
destination LAN and ultimately the addressed device. The bridge will similarly
recognize a packet addressed to the particular device and conveyed in the
5   primary cable medium and transfer the packet to the LAN in which the device is
located. The process of recognizing a device and providing packet transferring
services to the device is referred to herein as "registration." A device receiving
such packet transferring services is referred to herein as being "registered" with
such packet transferring apparatus. The registration process associated with a
10   conventional bridge is entirely "transparent" to the network. Although a device
must be registered with the bridge to receive packet transferring services, a
network device never addresses the bridge nor seeks to determine the presence
of a bridge before attempting to transmit packets to a device in another LAN.

          It is sometimes desirable to couple a portable device to such a
15   network without requiring wiring to a router or to the primary cable medium.
For example, it might be advantageous to permit a personal computer or
terminal to be operated anywhere in an office complex to access data from a
mainframe computer. In an automated system for identifying grocery prices, a
battery-operated hand-held unit might be used to scan bar-codes identifying a
20   particular product on display shelves. The scanned data can then be transmitted
to a central computer that returns the price currently recorded and applied to
purchase of the product at cash registers, for comparison with displayed prices.
A battery-operated hand-held unit may also be used during physical inspection
of inventories, allowing an individual to identify types and quantities of
25   products and to transmit such data to a central computer that updates inventory
records.

          Present practices respecting coupling of portable devices
generally involve multiple spaced-apart transceivers. Broadcasting regulations
often restrict the transmission power of any single source. General concern
30   regarding possible harmful effects of excessive electromagnetic radiation may
itself necessitate limited transmission power. Transceiving devices may
consequently be connected to the primary cable medium of the network at
various spaced-apart locations, each serving portable devices in a particular
limited area. Repeaters may be used to relay packets through air where direct
35   connection of a transceiver to the primary cable medium is inconvenient. The
various areas served by the transceiving devices and repeaters will be
overlapped to ensure continuous communication with mobile devices
throughout an office or industrial complex.

Several shortcoming exist in such conventional practices. When a packet addressed to a particular portable device is transmitted along the cable medium, each transceiving device of the network transmits the packet through air, regardless whether the portable device is within its area. If two or more

5   transceiving devices detect a packet from a portable unit, each causes a separate copy of the packet to be conveyed along the primary cable medium. Conventional packet handling routines provide methods for eliminating duplicate packets. However, such routines require some processing time, and multiplication of packets, particularly in a large network, can have deleterious

10   effects on the overall rate at which data is transmitted throughout the network. The problem is aggravated by conventional error checking practices that result in re-transmission of packets from an original source when transmission errors arise. Radio transmission of packets is generally subject to higher error rates than conventional transmission over cables.

15   Another shortcoming in conventional practices relates to operation of battery–powered portable units. Transmission or receipt of packets can place considerable current demand on a small battery and can severely shortens its useful life. It is now common to shut off the transmitter of a battery-powered unit between its transmissions. The receiver must, however,

20   remain operative as conventional network practice assumes that a device will be continuously "listening" for packets addressed to it. With typical current drain of several hundred milliamperes, two standard AA batteries might be expected to have a life in the order of minutes. One proposed arrangement is to discontinue all network communications with a battery-operated device until

25   certain keys associated with the device are operated. That may be effective where the device initiates all communications between itself and other network devices, but it is not a realistic solution for a large-scale network where multiple devices in remote LAN's may wish at any time to transmit packets to the portable device.

30   The present invention in its different aspects provides novel communication controllers and novel methods of placing portable devices in communication with networks and addresses various shortcomings associated with prior practices.

Disclosure Of The Invention

35   In one aspect, the invention provides a method of placing and maintaining a portable unit in wireless communication with the cable medium of a network for transfer of data packets via the cable medium to and from the portable unit. The method involves use of a plurality of communication

controllers coupled to the cable medium for transfer of packets and also adapted
to transmit and receive packets through air. Each communication controller
requires registration of the portable unit before transferring packets between the
portable unit and the cable medium. The portable unit is registered with one of
the communication controllers with a registration process comprising
transmitting through air from the portable unit a packet requesting a response
from communication controllers. Each controller receiving the packet responds
by transmitting through air (optionally in response to one or more criteria such
as capacity to accommodate the portable unit) a response packet identifying the
controller and indicating that the controller may register the portable unit. The
portable unit responds to receipt of one or more response packets by selecting
one of the responding controllers and transmitting through air from the portable
unit a selection packet indicating the selected controller. The selected controller
responds to receipt of the selection packet and optionally in response to one or
more criteria (such as then current capacity to accommodate the portable unit) by
registering the portable unit. Packet transmissions between the portable unit
and the selected controller are thereafter monitored at the portable unit to detect
transmission faults, and the registration process is re-initiated at the portable
unit. Transmission faults may include a series of lost packets (detected when a
controller fails to acknowledge transmitted packets), repeated errors in received
packets detected by conventional error checking routines, poor signal strength,
or an excessively low signal-to-noise ratio. According to this arrangement, a
portable unit selectively registers with a controller to receive packet transferring
services thereby avoiding the need to simultaneously transmit or detect packets
at several transceiving devices.

To reduce the incidence of duplicate packets, any controller with
which the portable unit is registered preferably detects conditions indicating that
further transfer of packets between the portable unit and controller is not
required and then de-registers the portable unit. Such a condition may be as
simple as expiry of an arbitrary predetermined period of time without receipt of
a packet through air from the portable unit. This criterion may be met, for
example, when the portable unit leaves the LAN served by the controller or
shuts off. An additional or alternative condition may involve receipt via the
cable medium of a packet indicating that the portable unit has registered with
another of the controllers. The controller may then de-register portable unit,
effectively ceasing any further transmission of packets addressed to the portable
unit and received via the cable medium from other network devices.

In another aspect, in a network of the general type described

above, the invention provides a method of reducing packet loss during registration of a portable unit with a second network communication controller in response to packet transmission faults between the portable unit and a first network communication controller with which it had been registered. The

5   method comprises storing packets addressed to the portable unit and received by the first controller in a buffer of the controller. A registration–indicating packet is transmitted from the second controller via the cable medium upon registration of the portable unit with second controller. In response to receipt of the registration–indicating packet, the first controller transmits via the cable medium

10   any undelivered packets addressed to the portable unit and stored in its buffer. The transmitted packets are then received and stored by the second controller in a buffer for re-transmission to the portable unit.

In another aspect, the invention reduces power requirements for operation of a battery-powered hand–held unit coupled by a wireless link to a

15   communication controller associated with a network and coupled to a cable medium associated with a network for packet transfers to and from the network. Specifically, battery current that might be required to continuously operate a receiving block to detect packets is reduced. The method comprises storing packets received by the communication controller and addressed to the portable

20   unit in a buffer prior to transmission to the portable unit. Polling packets are transmitted at intervals through air from the portable unit. The term "polling packet" as used in this specification indicates a packet that causes a transmitted response from a device receiving the packet. Delivery of battery current required to operate the receiving block is enabled for a predetermined period of

25   time following transmission of each polling packet and otherwise disabled between transmission of polling packets in such a manner as to reduce battery current demands. Stored packets addressed to the portable unit are transmitted through air from the controller only in response to receipt of polling packets from the portable unit and only within a preselected period of time following

30   receipt of each polling packet. The preselected period corresponds substantially to the predetermined period during which delivery of the required current to the packet-receiving block is enabled.

The invention also involves apparatus for use in implementing the methods described above. Such apparatus and other aspects of the

35   invention will be apparent from a description below of a preferred embodiment. Various aspects of the invention are more specifically defined in the appended claims.

Brief Description of the Drawings

The invention will be better understood with reference to

drawings in which:

fig. 1 is schematically illustrates a network comprising portable units coupled to a cable medium by radio links for transmission of data in packet form;

fig. 2 is schematically illustrates the principal components of a hand-held portable unit;

fig. 3 is schematically illustrates the principal components of a network controller adapted to communicate with the portable unit.

Best Mode of Carrying Out the Invention

Reference is made to fig. 1 which illustrates a network embodying the invention. The network comprises a cable medium, namely, an ethernet™ cable 10, along which all network data packets are transmitted when conveyed between any two network nodes. The principal nodes are direct–wired to the cable 10. These include a work station 12 and a network server 14, but may include a mainframe computer, communication channels, shared printers and various mass storage. These also include communication controllers C1, C2, C3. A fourth communication controller C4 effectively operates as a repeater, coupled to the cable 10 by the controller C3 and a radio link with the controller C3. It has been termed a "communication controller" because it registers portable units in the same manner as the communication controllers direct–wired to the cable 10 and offers the same basic registration services to the portable units. The controller C4 and each device to which it offers packet transferring services will, however, be registered with the controller C3 to ensure that packets intended for or transmitted by devices associated with the controller C4 are properly directed through the controller C4.

Several LAN's are present in the network illustrated. These LAN's are not specifically indicated, but each is effectively defined by the area which a single controller can serve, given limited transmission power, and the devices within that area. One LAN is served by the controller C1 and currently contains a portable unit 16, such as a line–powered personal computer, and a battery–powered hand–held unit 18. A second LAN is served by another controller C2 and currently contains two portable units 20, 22. A third LAN is served by the other wired controller C3 and also contains two portable units 24, 26. A fourth LAN is served by the controller C4, and no network device is currently within the range of that controller. The cable 10 and its nodes are also treated effectively as a LAN. It should be noted that all transmission between devices in different LAN's is via the cable 10. Only transmissions between

devices in a single LAN avoid using the cable 10, but such matters are not
discussed extensively herein.

5   The configuration of the controller C1 which is typical is shown
in fig. 3. It comprises a conventional transmitting/receiving block 28 that
transfers packets to and from the cable 10. A packet processor 30 handles the
packets received from the cable 10. A received packet will normally contain an
address identifying an network node (device address). The cable packet
processor 30 searches through a routing table constituted by a context
10   addressable memory 32 (CAM) to locate an entry containing the address. That
routing table contains network addresses only of the LAN members currently
registered with the controller C1. If the address contained in the received packet
is not found, the packet is simply discarded. Otherwise, the cable packet
processor 30 retrieves additional information from the CAM 32 regarding the
LAN member to which the packet is addressed. A CAM is preferred for such
15   purposes because of the speed of information retrieval achieved. Alternatively,
a more conventional arrangement information retrieval system can be
implemented with multiple registers with sequentially addresses, each register
containing information for a particular LAN device and an appropriate register
address being assigned and located, for example, by adding a constant offset to
20   the network address of the device. The alternative arrangement has the
disadvantage that a large number of registers may be required.

The additional information retrieved from the CAM 32 for a
particular LAN device will identify whether the addressed device is
battery-powered and requires a power-saving protocol. It will also identify
25   whether the device is mobile and whether packets addressed to the device
should receive special treatment to accommodate movement. If the information
indicates that no special treatment of the LAN device is required, the cable
packet processor 30 simply stores the packet in a conventional first-in, first-out
(FIFO) buffer 34. A radio packet processor 36 normally assembles packets
30   from the FIFO buffer 34 into a form appropriate for transmission to LAN
devices. It causes these packets to be transmitted by a transceiver 40 and
associated antenna 42 in the order in which the packets were originally received.

If retrieved information indicates that power saving or
accommodation of movement is required, the cable packet processor 30 stores
35   the packet in a random access buffer 38. All such packets addressed to a
particular LAN device are stored as a linked list in order of receipt. A pointer to
the first packet in the list is stored in the routing table along with the other data
respecting the LAN device. Packets intended for any particular device can

consequently be located quickly in the random access buffer 38. The FIFO
buffer 34 in contradistinction is simply maintained as a list of packets in order
of receipt without regard to the intended recipient of the packet. The manner in
which packets stored in the random access buffer 38 are ultimately transmitted
5   to LAN devices will be discussed further below.

The radio packet processor 36 stores packets received from LAN
devices in the FIFO buffer 34 unless the packet is intended for another portable
LAN member. In the latter case, the packet will be stored by the radio packet
processor 36 in the RAM buffer. The cable packet processor 30 retrieves
10   packets addressed to devices external to the associated LAN periodically from
the FIFO buffer 34 and conveys them along the cable 10. Devices at principal
nodes of the network are adapted to handle such packets directly, in a
conventional manner, if addressed to such devices. The other network
communication controllers process such packets in substantially the manner
15   described above and direct them to their respective LAN members if
appropriately addressed.

Packets received from LAN members observing power saving
protocols will generally contain a bit indicating the nature of the LAN member.
The radio packet processor 36 responds to the packet and implements power
20   saving routine. This will be discussed in greater detail below, following a
description of the operation of the battery-operated hand-held unit 18.

The hand-held unit 18 is diagrammatically illustrated in fig. 2.
A transmitting/receiving block 44 with associated antenna 46 transmits and
receives packets. A packet processor 48 assembles packets from data received
25   from an application processor 50 for transmission. The packet processor 48
also processes packets received by the transmitting/receiving block 44,
transferring received data to the application processor 50. The packet processor
48 performs conventional functions such as discarding packets not address to
the hand-held unit 18, error checking, and the like. The application processor
30   50 performs whatever general or specialized functions the hand-held unit 18 is
intended to perform, which may, for example, be directed to the inventory or
price checking discussed earlier. As long as standard packet protocols are
observed, the application processor 50 operates entirely independent of the
packet processor 48.

35   The hand-held unit 18 is powered with a battery 52. Battery
current is delivered to both the packet processor 48 and the
transmitting/receiving block 44 through a switch 54. A controllable timer 56 is
adapted to apply control signals to the switch 54 to place the switch 54 in either

ON or OFF states, respectively enabling or disabling flow of battery current to both the packet processor 48 and transmitting/receiving block 44. The application processor 50 is adapted to apply a signal to trigger the switch 54 to its ON state at any time that data is to be transmitted (overriding the power

5   saving protocol otherwise implemented). The packet processor 48 controls the switch 54 indirectly through the timer 56 to place the switch 54 in its OFF state, and simultaneously initiates counting by the timer 56 through a period of time specified by the packet processor 48. The timer 56 is configured to trip the switch 54 to its ON state once the period of time has expired thereby enabling

10   flow of battery current once again to the processor 48 and the transmitting/receiving block 44. Static random access memory (RAM) 58 permits the packet processor 48 to store various parameters while power is disabled.

Packet transmission to and from the hand–held unit 18 is

15   regulated by a polling process in which the hand–held unit 18 is dominant and a controller is subservient. This will be discussed with reference to the controller C1. The packet processor 48 of the hand–held unit 18 causes a polling packet to be transmitted to the controller C1. The polling packet may itself contain data received from the application processor 50 and intended for delivery to another

20   network node. The polling packet may alternatively be an empty packet effectively querying the controller C1 for transmission of any packets addressed to the hand–held unit 18 and stored in the controller's random access buffer 38. Following transmission of the polling packet, the packet processor 48 remains active until a response packet is received from the controller C1 or expiry of a

25   period of roughly 10 milliseconds. The packet processor 48 then initiates operation of the counter, specifying the counting period, which may for example be 200 milliseconds (exemplary and variable), and effectively trips the switch 54 to its OFF state. This disables battery current to both the packet processor 48 and the transmitting/receiving block 44. When the timer 56

30   completes counting through the set period of 200 milliseconds, it trips the switch 54 to its ON state, once again enabling the packet processor 48 and the transmitting/receiving block 44. The packet processor 48 immediately causes transmission of a polling packet. This basic process is repeated (subject to adjustment of polling rates described below), allowing both communication

35   with the hand–held unit 18 and power saving.

The radio packet processor 36 of the controller C1 responds to each polling packet (identified with an appropriate control bit to indicate a power saving requirement) from the hand–held unit 18 essentially as follows. It scans the table maintained in the CAM 32 for the entry containing the network address

of the hand–held unit 18. That source address is of course contained in each polling packet following conventional packet transmission protocols. It checks the field of the entry that contains the pointer to the linked list of packets stored in the random access buffer 38 and addressed to the hand–held unit 18. If a

5 null pointer is present, indicating no pending packets, the radio packet processor 36 causes an empty response packet to be transmitted to the hand–held unit 18, acknowledging receipt of the polling packet. Otherwise, it locates the first packet addressed to the hand–held unit 18 from the random access buffer 38, causes the packet to be transmitted to the hand–held unit 18,

10 and updates the pointer stored in the CAM 32 to identify the next in the list of relevant packets or to indicate a null pointer. The retrieval and transmission process is completed within the exemplary 10 millisecond period during which the packet processor 48 of the hand–held unit 18 and its transmitting/receiving block 44 remain enabled.

15 The power saving protocol is preferably modified to accommodate the rate of data transmission to the hand–held unit 18. This is done specifically by varying the polling rate and the period of time during which battery current flow is disabled, inversely related factors. The packet processor 48 of the hand–held unit 18 may be appropriately programmed to poll the

20 controller C1 initially at about 2 second intervals. The packet processor 48 effects such a polling rate by specifying a timer counting period of about 2 seconds. Each time a non–empty response packet is received by the hand–held unit 18 from the controller C1, the packet processor 48 roughly doubles the polling rate, effectively by dividing the counting period it specifies for the

25 counter in half. This doubling of the polling rate may continue until the polling interval approaches the 10 millisecond time–out period in which a controller response must be received. Each time that an empty response packet is received from the controller C1, the polling rate may be divided in half by the packet processor 48 (by doubling the counting period specified for the timer 56) until

30 the maximum polling period of 2 seconds is restored. Such operation effectively increases the polling rate in response to the rate at which the network transmits data to the hand–held unit 18. The hand–held unit 18 does not become a severe bottle–neck in the transmission stream. When the transmission rate is low, the polling rate is reduced, incidentally reducing requirements for

35 battery current.

General operation of the network to accommodate movement of the hand–held unit 18 will be described. The hand–held unit 18 is assumed to be registered initially with the controller C1. The controller C1 is also assumed

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to have undelivered packets addressed to the hand–held unit 18 and stored in its random access buffer 38. The hand–held unit 18 is assumed then to move to position A, illustrated in phantom outline in fig. 1, assumed to be beyond the transmission range of the controller C1. The hand–held unit 18 transmits

5   polling packets at intervals, following its power–saving routine, with no response from the controller C1. After a predetermined number of attempts to poll the controller C1, the packet processor 48 of the hand–held unit 18 causes transmission of a packet requesting registration with a network communication controller and providing its unique network address or identification. That

10   packet preferably contains a bit identifying it as a control packet to trigger appropriate processing by the radio packet processors of any controller. The packet may be stored in the FIFO buffers associated with each controller receiving the packet and in practice may simply be processed in the normal order associated with received packets. The registration–requesting packet is

15   assumed in this instance to be received only by the controllers C2 and C3.

In this embodiment of the invention, the radio packet processor associated with each controller is adapted to register only a fixed number of devices in its LAN. The controllers C1 and C2 scan their respective routing tables to determine how many devices they have registered and whether the

20   hand–held unit 18 can be accommodated. This is referred to as searching for an "empty registration slot." It is assumed that both controllers C2 and C3 can accommodate another device. Each then transmits a response packet addressed to the hand–held unit 18 and each reserves a registration slot for a predetermined period of time. Each response packet will include the

25   controller's unique network address and will also indicate the number of hops from the controller to the cable 10. A controller connected directly to the cable 10 is regarded as 0 hops from the cable 10. A controller that functions as a repeater returns a positive number indicating the number of intervening controllers (hops) required to couple it to the cable 10.

30   The hand–held unit 18 then responds to the controller response packets by selecting one of the responding controllers C2, C3. The selection is made according to the number of hops to the cable 10, signal strength (detected in a conventional manner), and which response packet is first received, priority being assigned in that order. In the present case, governed by the second

35   criterion, namely, signal strength, and assuming that the closer controller C2 produces a stronger received signal, the hand–held unit 18 selects the controller C2. The hand–held unit 18 then transmits a selection packet addressed to the controller C2 requesting registration. The selected controller C2 responds to the

selection packet by registering the hand-held unit 18 and begins the process of
monitoring the cable 10 for packets addressed to the hand-held unit 18. It also
recognizes and conveys to the cable 10 any data packets received from the
hand-held unit 18. The controller C3, not selected, but within range, does not

5   respond to packets in the cable 10 addressed to the hand-held unit 18 and does
not respond to any data packets received from the hand-held unit 18. No
duplicate packets are produced within the cable 10 and no duplicate packets are
transmitted through air.

    Contemporaneously with registration, the selected controller C2

10   transmits via the cable 10 a universal packet indicating its registration of the
hand-held unit 18. The universal packet contains a unique address to which all
network controllers. This is conveyed via the cable 10 to the controller C1 with
which the hand-held unit 18 had been registered. The controller C1 responds
by immediately de-registering the hand-held unit 18, discontinuing monitoring

15   of the cable 10 for packets addressed to the hand-held unit 18 and disregarding
further packets of a general nature transmitted by the hand-held unit 18 and
possibly received by the controller C1. The controller C1 also responds by
transmitting along the cable 10 any undelivered packets contained in its random
access buffer 38 that are addressed to the hand-held unit 18. The newly

20   selected controller C2 retrieves the packets from the cable 10 and stores them in
its random access buffer for re-transmission to the hand-held unit 18.
Conventional network protocols provide a general mechanism for sorting
packets, and in many instances, no special steps are required to ensure that the
stored packets are transmitted and re-stored in a particular order. However, a

25   preferred practice is to incorporate a sequencing field into each packet indicating
the total number of packets being transferred and the particular order of the
particular packet relative to the total number. Storage of the packets in the
random access buffer of the controller C2 may then involve reconstructing a
linked list of the packets in precisely the same order as originally maintained by

30   the controller C2. The hand-held unit 18 polls the controller C2 in the manner
described above to retrieve such packets.

    The hand-held unit 18 may then move to position B shown in
phantom in fig. 1. It is assumed now to be out of range of the controller C2 but
still within the range of controllers C3, C4. After predetermined attempts to

35   contact the controller C2 with polling packets, the hand-held unit 18 sends a
packet requesting registration with a communication controller. It receives
response packets only from the controllers C3, C4. The packet from controller
C4 will indicate that the controller C4 is one hop away from the cable 10, that

is, the controller functions as a repeater. The packet from the controller C3 indicates direct connection to the cable 10 (zero hops). The hand–held unit 18 consequently selects the controller C3 according to the criteria specified above, and transmits a packet requesting registration with the controller C3. The

5 controller C3 responds with response packet confirming registration, assuming no intervening registrations have taken the full capacity of the controller C3. If the capacity of the controller were somehow taken, the hand–held unit 18 would repeat transmission of its selection packet, assume transmission failure, and re–initiate the process of locating an appropriate communication controller. The

10 controller C3 also transmits via the cable 10 a universal packet addressed to controllers indicating the registration, and the controller C2 de–registers the hand–held unit 18. The controller C2 transmits any undelivered packets addressed to the hand–held unit 18 along the cable 10, and the new controller C3 detects and stores the packets. In effect, the controller C3 is fully

15 conditioned to continue packet transmission from where the last controller lost communication with the hand–held unit 18. No packets are lost.

In position C illustrated in phantom in fig. 1, the hand–held unit 18 is assumed to be out of range of all controllers except the controller C4. With repeated failure in transmission of packets to the controller C3, the

20 hand–held unit 18 transmits a packet requesting registration with a controller. Only the controller C4 responds by transmitting an appropriate packet. The selection process at the hand–held unit 18 is simplified, the only criterion to be applied is that a controller responded and was effectively the first controller to respond. The hand–held unit 18 then transmits its selection packet identifying

25 the controller C4 and requesting registration. The controller C4 registers the hand–held unit 18, and transmits a universal packet via the cable 10 addressed to controllers confirming the registration. The controller C3 actually places the packet on the cable 10.

The controllers C1–C4 effectively replace the prior art

30 transceiving devices used to couple a portable device to a wired network. Their overall operation may to some extent be viewed as a hybrid of router and bridge operation with a particular registration protocol superimposed. Like a router, each will be addressed by the devices within its LAN. Unlike most conventional routers, the controllers C1-C4 do not maintain a table of LAN's

35 within the network. The operating assumption is that a packet addressed to a particular device, if transmitted by a router "via" the cable 10 (that is, if the cable 10 forms part of the transmission path) will ultimately be detected by another controller with which the particular device is registered. Like a bridge,

the controllers C1-C4 are effectively aware of the devices in their associated LAN (although not devices in other LAN's) and the devices in their associated LAN are registered with them before receiving packet transferring services. Unlike a conventional bridge, the controllers C1–C4 must be addressed and require involvement of a device in the registration process. That requirement avoids the tendency to produce duplicate packets and allows fast re-routing of packets as devices move throughout the LAN's.

A number of alternatives might be considered. The communication controllers may be programmed not to reserve a registration slot for a particular device transmitting a request for registration. If another device is registered in the meantime, taking a last empty registration slot, the selected controller may simply not respond to transmission and re-transmission of a selection packet from the particular device. The particular device will treat this as another transmission fault, and repeats the registration process, effectively seeking an alternative controller. Another alternative, which may practical for many small networks, is to operate on the assumption that each controller will be obliged to register no more than a fixed number of devices. Communication controllers for such applications may have CAM's or other memory units containing registration slots in excess of that fixed number and can be programmed always to offer registration to every device transmitting an appropriate selection packet. Specific details of implementation can be greatly varied. For example, the cable and radio packet processors associated with each controller may be constituted by a single processor performing dual functions. The FIFO buffer of each controller has been depicted as a single unit in which both packets received and to be transmitted (as to non–portable devices), but could be replaced by separate and distinct storage media.

It will be appreciated that a particular embodiment of the invention has been described and that further modifications may be made therein without departing from the spirit of the invention.

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Claims

1.   In a network comprising a cable medium conveying packets between predetermined nodes, a portable unit capable of transmitting and receiving packets through air, and a plurality of communication controllers in a predetermined spaced–apart arrangement, each of the plurality of controllers being capable of transmitting and receiving packets through air within a limited area and being coupled to the cable medium for transfer of packets to and from the cable medium, each of the plurality of controllers requiring registration of the portable unit with the controller before transferring packets between the portable unit and the cable medium, a method of placing and maintaining the portable unit in wireless communication with the cable medium for transfer of packets via the cable medium to and from the portable unit, comprising:

        registering the portable unit with one of the plurality of controllers with a registration process comprising:

(a)   transmitting through air from the portable unit a packet requesting a response from each of the plurality of controllers;

(b)   responding to the request for response at each of the controllers that receives the packet from the portable unit, the responding comprising transmitting through air optionally in response to at least one predetermined criterion a response packet identifying the controller and indicating that the controller may register the portable unit;

(c)   responding at the portable unit to receipt of one or more controller response packets by selecting one of the responding controllers and transmitting through air from the portable unit a selection packet indicating the selected controller; (d)

        responding at the selected controller to receipt of the selection packet and optionally in response to at least one predetermined criterion by registering the portable unit with the selected controller;

        monitoring transmission of packets between the portable unit and the selected controller at the portable unit after registration of the portable unit with the selected controller thereby to detect transmission faults and re–initiating the registration process at the portable unit in response to transmission faults.

2.   The method of claim 1 in which the registration process is adapted to de-register the portable unit from another of the controllers with which the portable unit had been registered prior to registration with the selected controller, the registration process further comprising:

        transmitting via the cable medium from the selected controller

upon its registration of the portable unit a registration–indicating packet indicating that the selected controller has registered the portable unit; and,

responding to receipt of the registration–indicating packet at the other controller by de–registering the portable unit from the other controller.

5 3.   The method of claim 2 in which each of the controllers is adapted to store packets addressed to the portable device and received by the controller prior to transmission of such packets by the controller through air to the portable unit, the method being adapted to recover any undelivered packets stored by the other controller with which the portable unit had been registered,

10 the registration process further comprising:

responding to the registration–indicating packet at the other controller by transmitting the undelivered packets via the cable medium to the selected controller; and,

receiving and storing the transmitted undelivered packets at the

15 selected controller for transmission through air to the portable unit.

4.   The method of claim 1 comprising detecting at any one of the controllers with which the portable unit is registered a predetermined condition indicating that further transfer of packets between the portable unit and controller is not required and de–registering the portable unit from the controller

20 in response to detection of such a condition.

5.   The method of claim 4 in which the predetermined condition at the any one of the controllers is one of (a) expiry of a predetermined period of time without receipt of a packet through air from the portable unit and (b) receipt via the cable medium of a packet indicating that the portable unit has registered

25 with another of the controllers.

6.   The method of claim 1 in which the portable unit is operated with a battery that delivers electric current required for operation of a packet–receiving block of the portable unit, the method further comprising:

storing packets received by the selected controller and addressed

30 to the portable unit in a buffer associated with the selected controller;

transmitting at intervals through air from the portable unit a polling packet;

enabling delivery of the required electric current for a predetermined period of time following transmission of each polling packet

35 from the portable unit and so disabling delivery of the required electric current between transmission of polling packets that current demands on the battery are reduced; and,

transmitting stored packets addressed to the portable unit

through air from the selected controller only in response to receipt of polling
packets from the portable unit and only within a preselected period of time
following receipt of each polling packet from the portable unit, the preselected
period corresponding substantially to the predetermined period during which

5   delivery of the required current to the packet-receiving block is enabled.

7.   The method of claim 6 further comprising decreasing the interval
between transmission of successive polling packets incrementally toward a
predetermined lower limit in response to receipt at the portable unit of each
stored packet addressed to the portable unit and transmitted through air by the

10   selected controller.

8.   The method of claim 7 further comprising:

                transmitting a predetermined response packet addressed to the
portable unit in response to each polling packet received by the selected
controller from the portable unit in the event that the buffer of the selected

15   controller contains no stored packet addressed to the portable unit; and,

                increasing the interval between transmission of successive
polling packets incrementally toward a predetermined upper limit in response to
receipt at the portable unit of each predetermined response packet addressed to
and received by the portable unit.

20   9.   In a network comprising a cable medium conveying packets
between predetermined nodes, a portable unit capable of transmitting and
receiving packets through air, and a plurality of communication controllers in a
predetermined spaced-apart arrangement, each of the plurality of controllers
being capable of transmitting and receiving packets through air within a

25   predetermined area and being coupled to the cable medium for transfer of
packets to and from the cable medium, the portable unit being operated with a
battery that delivers electric current required for operation of a packet-receiving
block of the portable unit, the portable unit being registered with one of the
plurality of controllers during transfer of packets between the portable unit and

30   the cable medium, a method of reducing current demands on the battery of the
portable unit, comprising:

                storing packets received by the one controller and addressed to
the portable unit in a buffer associated with the one controller;

                transmitting at intervals through air from the portable unit a

35   polling packet;

                enabling delivery of the required electric current for a
predetermined period of time following transmission of each polling packet
from the portable unit and so disabling delivery of the required electric current

between transmission of polling packets that current demands on the battery are reduced;

transmitting stored packets addressed to the portable unit through air from the one controller only in response to receipt of polling packets from the portable unit and only within a preselected period of time following receipt of each polling packet from the portable unit, the preselected period corresponding substantially to the predetermined period during which delivery of the required current to the packet-receiving block is enabled.

10. The method of claim 9 further comprising decreasing the interval between transmission of successive polling packets incrementally toward a predetermined lower limit in response to receipt at the portable unit of each stored packet addressed to the portable unit and transmitted through air by the selected controller.

11. The method of claim 10 further comprising:

transmitting a predetermined response packet addressed to the portable unit in response to each polling packet received by the selected controller from the portable unit in the event that the buffer of the selected controller contains no stored packet addressed to the portable unit; and,

increasing the interval between transmission of successive polling packets incrementally toward a predetermined upper limit in response to receipt at the portable unit of each predetermined response packet addressed to and received by the portable unit.

12. The method of claim 9 adapted to recover undelivered packets addressed to the portable unit and stored in the buffer of the one controller in response to registration of the portable unit with another of the plurality of controllers, comprising:

transmitting from the other controller via the cable medium upon its registration of the portable unit a registration–indicating packet indicating that the other controller has registered the portable unit;

responding to the registration–indicating packet at the one controller by transmitting the undelivered packets via the cable medium to the other controller; and,

receiving the transmitted undelivered packets at the other controller and storing the undelivered packets in a buffer associated with the other controller for transmission to the portable unit.

13. In a network comprising a cable medium for conveying packets between predetermined nodes, a portable unit capable of transmitting and receiving packets through air, and a plurality of communication controllers in a

predetermined spaced–apart arrangement, each of the plurality of controllers being capable of transmitting and receiving packets through air within a limited area and being coupled to the cable medium for transfer of packets to and from the cable medium, each of the plurality of controllers requiring registration of

5   the portable unit with the controller before transferring packets between the portable unit and the cable medium, the portable unit being registered with one of the plurality of controllers, a method of reducing loss of packets during registration of the portable unit with another of the plurality of controllers in response to a transmission fault to or from the one controller, comprising:

10   storing packets addressed to the portable unit and received by the one controller for transmission to the portable unit in a buffer of the one controller while the portable unit is registered with the one controller;

                       transmitting from the other controller via the cable medium upon registration of the portable unit with the other controller a registration–indicating

15   packet indicating that the controller has registered the portable unit;

                       responding at the one controller to receipt of the registration–indicating packet by transmitting via the cable medium any undelivered packets addressed to the portable unit and stored in the buffer of the one controller; and

20   receiving the transmitted undelivered packets at the other controller and storing the undelivered packets in a random access buffer of the other controller for transmission through air to the portable unit.

       14.   The method of claim 13 further comprising de-registering the portable unit from the one controller in response to receipt of the

25   registration–indicating packet.

       15.   Apparatus for use in placing and maintaining a portable unit in wireless communication with a cable medium of a network for transfer of packets via the cable medium to and from the portable unit, the network comprising a plurality of communication controllers in a predetermined

30   spaced–apart arrangement, each of the plurality of controllers being capable of transmitting and receiving packets through air within a limited area and being coupled to the cable medium for transfer of packets to and from the cable medium, each of the plurality of controllers requiring registration of the portable unit with the controller before transferring packets between the portable unit and

35   the cable medium, the apparatus comprising:

                       means for transmitting and receiving packets through air;

                       control means for causing the portable unit to register with one of the controllers, the control means being adapted to implement a registration process comprising:

(a)   transmitting via the transmitting and receiving means a packet requesting a response from each of the controllers; and,

(b)   responding to receipt by the transmitting and receiving means of one or more response packets from the controllers, each response packet being

5   responsive to the response-requesting packet and identifying the responding control, by selecting one of the responding controllers according to at least one predetermined criterion and transmitting via the transmitting and receiving means a packet requesting registration with the selected controller;

          the control means being adapted to monitor transmission of
10   packets between the portable unit and the selected controller via the transmitting and receiving means thereby to detect transmission faults and to re-initiate the registration procedure at the portable unit in response to detected transmission faults.

16.   The apparatus of claim 15 adapted for use with a portable unit
15   powered by a battery and controllers that store packets addressed to the portable unit in buffers prior to transmission of such stored packets to the portable unit, in which:

          the transmitting and receiving means include a receiving block requiring current from the battery for receipt of packets;

20   the control means are adapted to cause the transmitting and receiving means to transmit at intervals a polling packet requesting transmission of packets addressed to the portable unit and stored in the buffer associated with the selected controller;

          the control means are adapted to enable delivery of the required
25   electric current for a predetermined period of time following transmission of each polling packet from the portable unit and otherwise to so disable delivery of the required electric current between transmission of polling packets that current demands on the battery are reduced.

17.   The apparatus of claim 16 in which the control means are
30   adapted to decrease the interval between transmission of successive polling packets incrementally toward a predetermined lower limit in response to receipt at the portable unit of each data-containing transmitted through air by the selected controller.

18.   The apparatus of claim 17 in which the control means are
35   adapted to increase the interval between transmission of successive polling packets incrementally toward a predetermined upper limit in response to receipt at the portable unit of each predetermined response packet transmitted by the selected controller and addressed to the portable unit that indicates the selected

controller has no data to transmit to the portable unit.

19.   A communication controller for placing a portable unit capable of transmitting and receiving packets through air in communication with a cable medium of a network for transfer of packets via the cable medium to and from the portable unit, comprising:

means for transmitting and receiving packets through air;

means for transferring packets to and from the cable medium;

a buffer;

control means for registering the portable unit with the controller in response to receipt of a packet transmitted through air by the portable unit and requesting registration of the portable unit with the controller, the control means being adapted to store packets received by the controller via the cable medium and addressed to the portable unit in the buffer for transmission to the portable unit upon registration of the portable unit with the controller;

the control means being adapted to respond to a packet received from another controller of the network and indicating registration of the portable unit with the other controller by transmitting any undelivered ones of the stored packets stored by the controller via the cable medium to the other controller.

20.   The communication controller of claim 19 in which the controller means are adapted to de-registered the portable unit from the controller in response to receipt by the controller of the registration-indicating packet from the other controller.

21.   The controller of claim 20 in which the control means are adapted to transmit via the cable medium upon registration of the portable unit with the controller a packet indicating registration of the portable unit with the controller thereby to initiate transmission of undelivered packets addressed to the portable unit and stored in any controller with which the portable unit was previously registered.
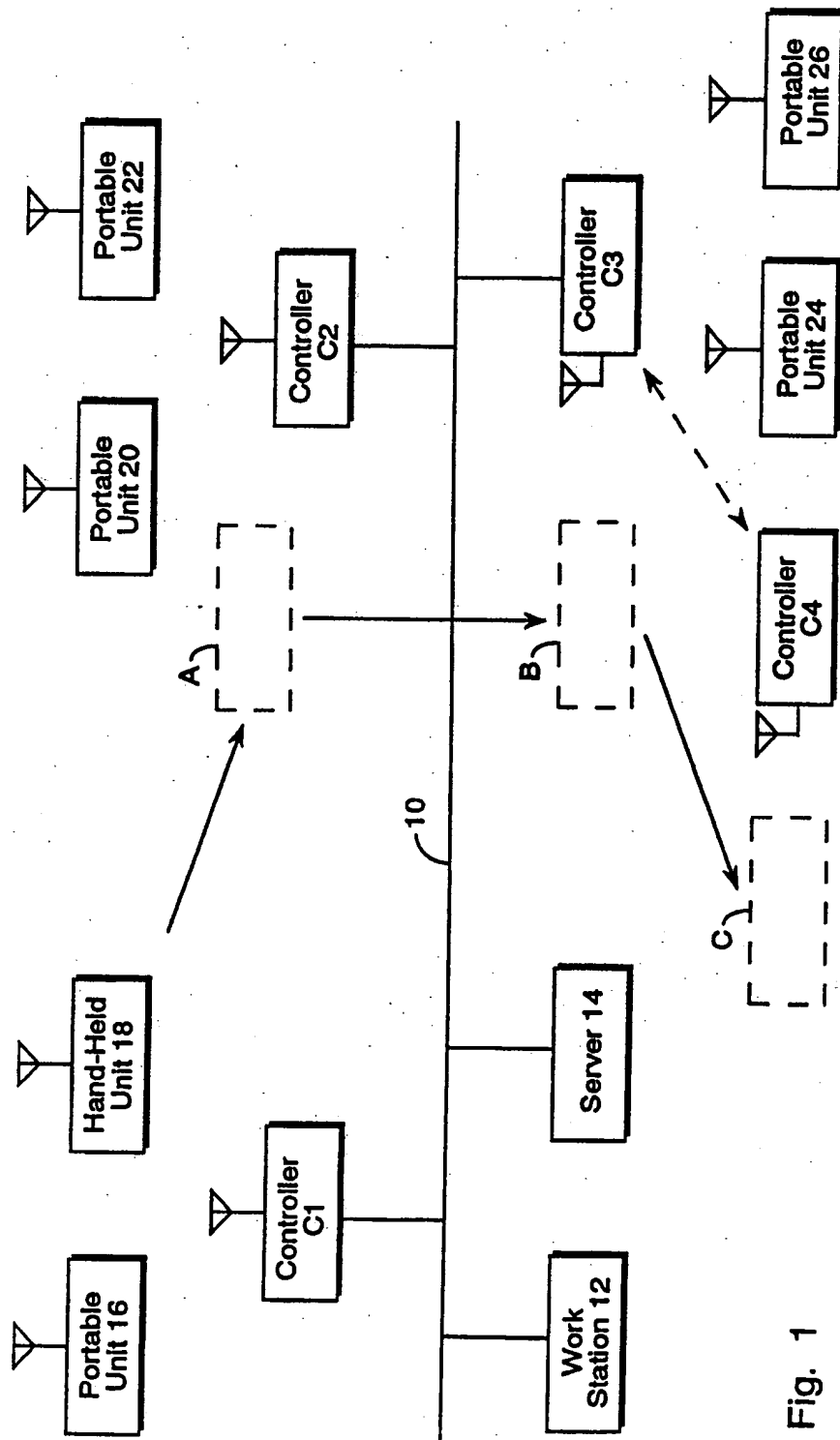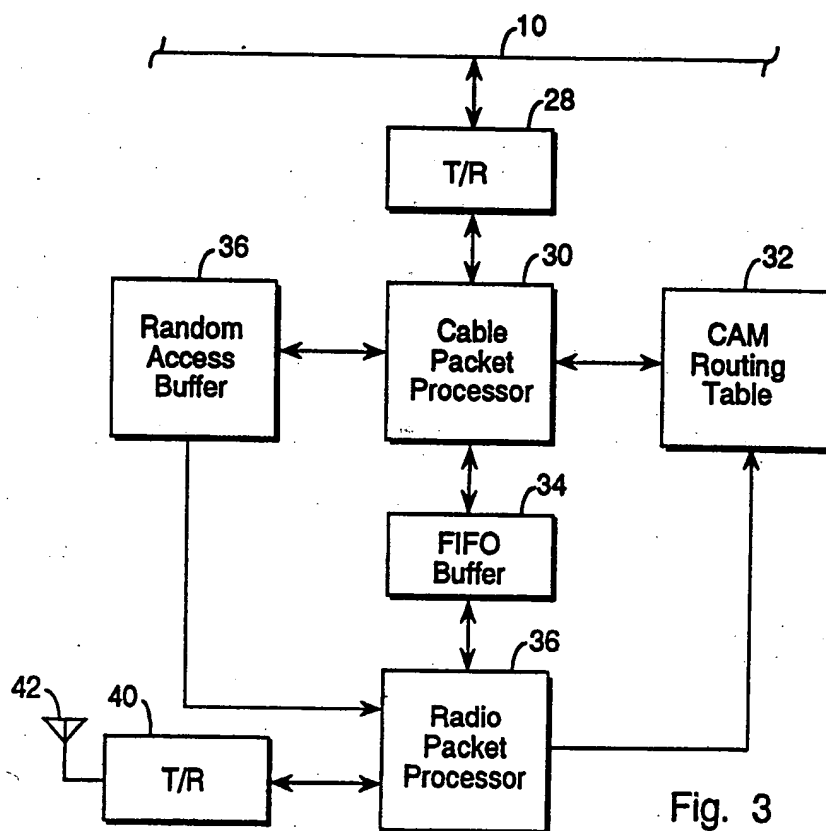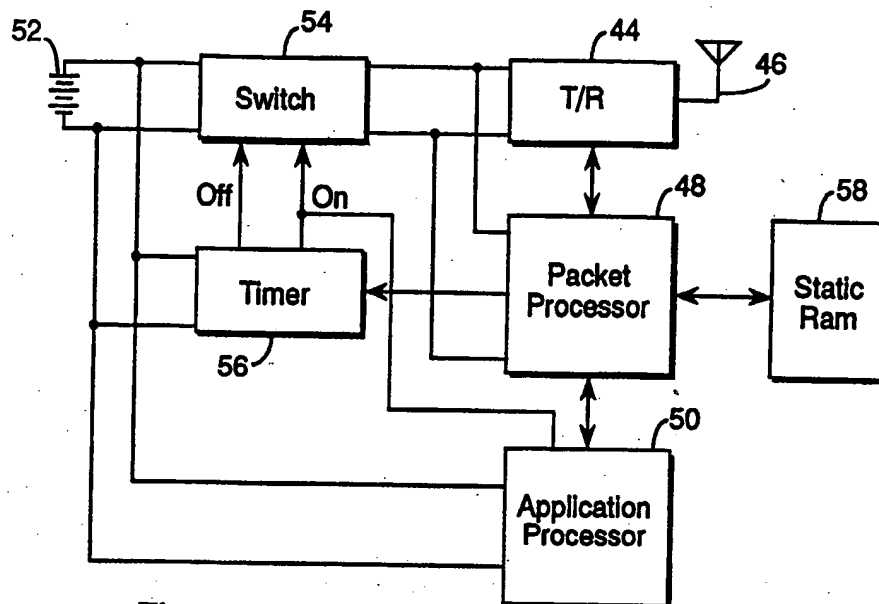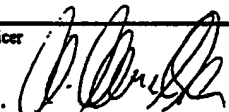
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Fig. 1

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Fig. 2

Fig. 3

INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H04L12/56;   H04Q7/04;   H04L12/28;   H04L12/40
H04B10/10

II. FIELDS SEARCHED

Minimum Documentation Searched[7]	
Classification System	Classification Symbols
Int.Cl. 5	H04L ; H04Q

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category[o]	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	EP,A,0 405 074 (SYMBOL TECHNOLOGIES) 2 January 1991	1
A	see column 3, line 23 - column 4, line 28	2-8, 10-21
X	see column 26, line 48 - column 27, line 30 ---	9
Y	EP,A,0 268 375 (NORTHERN TELECOM) 25 May 1988 see column 4, line 2 - line 48 see column 9, line 16 - column 11, line 51 ---	1
A	EP,A,0 221 708 (3M) 13 May 1987 see page 13, line 25 - page 14, line 9 ---	7,8,10, 11,17,18
A	EP,A,0 366 342 (AT&T) 2 May 1990 see column 6, line 51 - column 7, line 2 see column 11, line 25 - line 52 ---	1,13,15, 19

* Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
09 SEPTEMBER 1992	14. 09. 92
International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	MESSELKEN M.

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. CA 9200149
                                          SA   58071

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
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09/09/92

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